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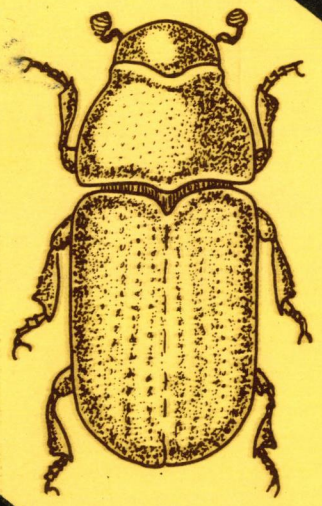
1979



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EVALUATING SPRUCE MORTALITY USING AERIAL INFRARED 70 MM PHOTOGRAPHY IN THE SANGRE DE CRISTO MOUNTAINS, CARSON NATIONAL FOREST, NEW MEXICO

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1979

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INTRODUCTION

Obtaining estimates of spruce sawtimber killed by the spruce beetle, Dendroctonus rufipennis (Kby.), is a difficult sampling task, especially over large, inaccessible acreages of forest land. On-the-ground surveys have been done to obtain these estimates, but they have proven to be too costly and impractical. Standard aerial detection surveys have provided basic information as to extent and location of tree mortality, but it is well-known that an estimate of dead stems per acre cannot be obtained by this approach. Lessard and Wilson (1977) showed that low-cost aerial photographic surveys could provide accurate estimates of dead stems per acre in large diameter pure stands of spruce. An aerial photographic mission was flown in 1977 to evaluate the feasibility of estimating spruce beetle-caused mortality in small diameter, mixed conifer stands.

SURVEY AREA

The survey area was located in the Sangre de Cristo Mountains, Carson National Forest, New Mexico (Fig. 1). A severe spruce beetle outbreak occurred in this area from 1961 to 1964. In an attempt to suppress this infestation, salvage logging and suppression logging of green infested trees was done. When these efforts failed, many infested stands were cabled down and burned (Lessard 1976).

OBJECTIVES

The objectives of this evaluation were twofold:

1. To evaluate the feasibility of estimating spruce beetle-caused mortality using medium-scale[1/] 70 mm color infrared photography in small diameter mixed conifer stands.

2. To provide the forest manager with a reliable estimate of tree mortality in the survey area.

METHODS

In 1977, stands of small diameter spruce beetle-killed trees and dead true fir trees were evaluated. A double sampling technique was used in this evaluation. This technique employs an aerial photographic and interpretation phase, and a ground truth phase. In the ground truth phase, a subsample of the photo plots is surveyed (100%) to determine the actual number of dead trees on those plots.

1/ In this type of survey, medium-scale photography was considered to be 1:4,000 to 1:8,000.

The aerial photographic phase was conducted on October 17, 1977. The aerial platform consisted of a Cessna 206 aircraft equipped with a 70 mm Hasselblad EL/M camera, an 80 mm lens, and Wratten 12 filter, using Kodak 2443 color infrared aerial film. The predetermined average photo scale was 1:5,000.

The 70 mm color infrared transparencies were interpreted by an experienced interpreter using standard techniques. A total of 58 (2.5-acre) stereo photo plots were interpreted. On each plot, the number of dead trees was recorded.

The ground truth phase was conducted in the spring of 1978. Five ground truth plots (8.6%) were selected for examination. Resource photography (1:15,840) was used for ground orientation in locating photo plots. A hand-held stereo viewer was used to view the photo plots on the 70 mm transparencies in the field for establishing plot boundaries. A clinometer and a 100-foot tape were used to measure one side of the plot boundaries of ground truth plots. Plot corners were staked, and string was used to delineate plot boundaries. All standing dead spruce trees due to the spruce beetle were recorded. Dead spruce trees not killed by the beetle were also recorded. All standing true fir mortality within the plots was recorded. Diameter at breast height (d.b.h.) was taken for all dead trees.

A regression estimator, using linear regression analysis between photo interpretation data and ground truth data, was used to provide an adjusted estimate of dead trees per acre over the entire 16,500-acre survey area.

RESULTS AND DISCUSSION

Three problems, common to many aerial photographic surveys, surfaced in this evaluation. The first of these involved large variations in ground elevation along all flight lines and improper aircraft altitude along some flight lines which necessitated correcting photo scale and plot size. Procedures for correcting photo scale and plot size are detailed by Avery (1966) and will not be discussed. The corrected photo scale varied from 1:1,687 to 1:11,288 (Table 1). The mean photo scale was 1:5,748 (C.V. = 37%). The corrected plot size was 2.78 acres per plot. The second problem involved an inability to differentiate between dead spruce and dead fir during photo interpretation. Therefore, in this evaluation, the number of dead spruce and fir trees per photo plot was recorded without reference to tree species or cause of mortality. The third problem involved an inability to interpret small diameter trees (trees less than 7-9 inches d.b.h.). Small diameter, suppressed trees could not be seen through the forest canopy; only dominant and codominant sawtimber-sized trees were visible.

A regression line (Fig. 2) was constructed comparing the number of dead spruce and fir trees in the photo plot interpretation against the actual ground truth (Table 2). For this regression, the coefficient of determination (r^2) was 0.96. An F-test showed that the regression line fit the data ($P < 0.005$). The problem involving an inability to interpret small diameter trees is seen in the regression line. Only about 50-60 percent of the actual dead spruce and fir from ground truth are seen during photo interpretation.

The adjusted mean tree count (yrd) is calculated from the following formula:

$$yrd = \bar{y}_2 + b(\bar{x}_1 - \bar{x}_2)$$

where:

$\bar{y}_2$ = mean tree count on 5-plot ground truth sample

b = slope of regression line $\hat{Y} = a + bX$

$\bar{x}_1$ = mean tree count on all 58 photo plots

$\bar{x}_2$ = mean tree count on 5-plot photo sample

The adjusted dead trees per acre, based on an average plot size of 2.78 acres, is 51.3 (Table 3). From ground truth data, stand composition is 50 percent dead spruce and 50 percent dead fir. Therefore, the estimated tree mortality for spruce and fir is about 25.65 trees per acre, respectively. The average diameter (greater than 9 inches d.b.h.) for dead spruce is 11.6 inches (d.b.h.) and for dead fir is 11.0 inches (d.b.h.). The estimated cubic foot volume of the entire stem per acre of dead spruce and fir is 464 ± 334 and 369 ± 203, respectively.

CONCLUSIONS

For assessing spruce and fir mortality in mixed conifer stands, medium-scale 70 mm aerial color infrared photography works well. Because dead spruce and fir trees cannot be separated during photo interpretation, spruce beetle damage assessment using medium-scale aerial photography is not recommended in mixed conifer stands.

LITERATURE CITED

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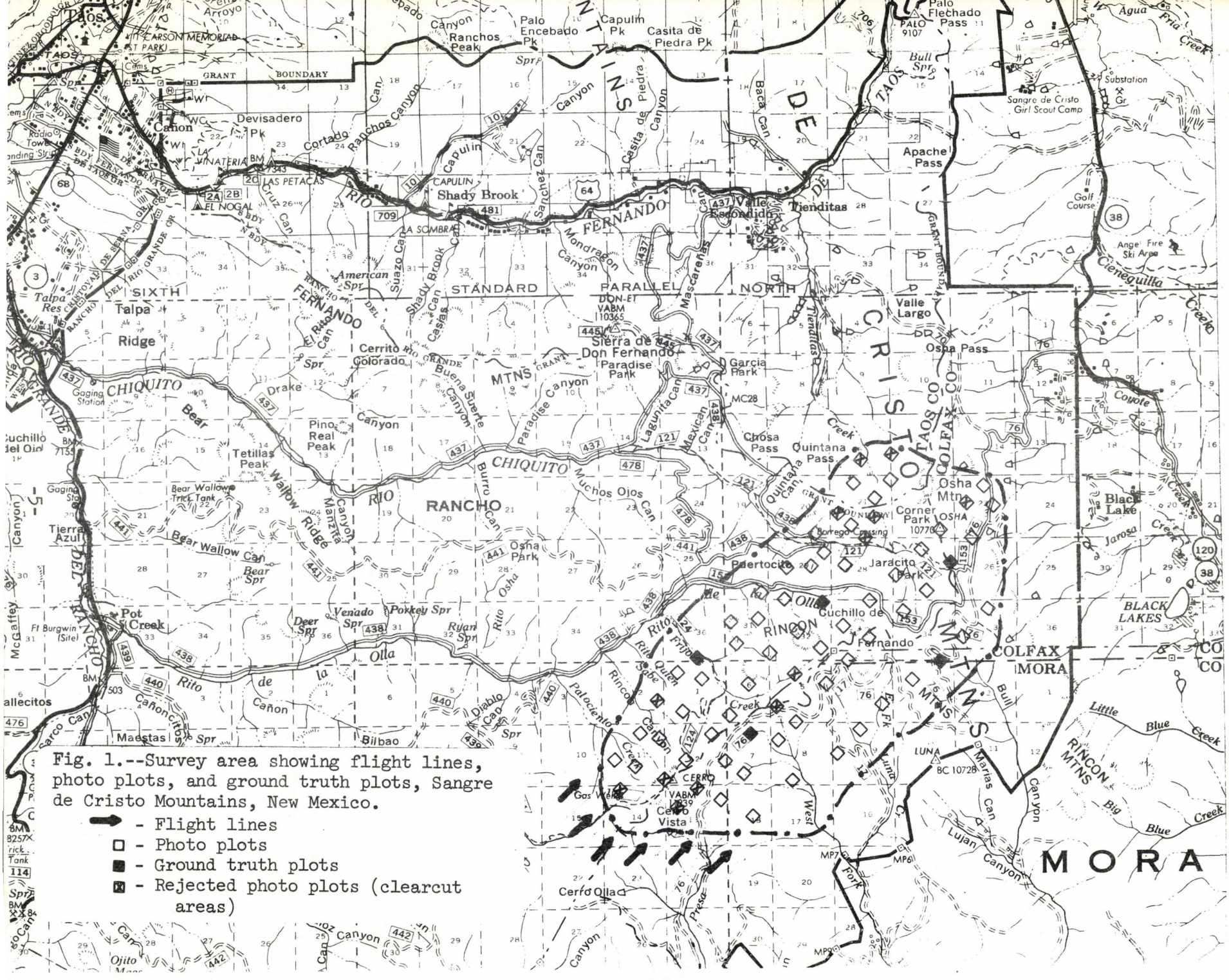
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Corner Park
Black Lake
Coyote Creek
Jarosa Creek
Bear Wallow Trick Tank
Bear Wallow Can
Tierra Azul
Osha Park
Puertocito
Jaracito Park
Borrego Crossing
BLACK LAKES
Pot Creek
Ft Burgwin (Site)
Deer Spr
Venado Spr
Pokkey Spr
Ryan Spr
Olla
Guchillo de Fernando
Maestas Spr
Bilbao
Cañoncito
Diablo Canyon
Palocientito Creek
Rincon Canyon
Cerro Vista
Gas Well
Cerro Olla
Luna
BC 10728
Marias Can
Lujan Canyon
Little Blue Creek
Big Blue Creek
RINCON MTNS
MP71
MP61
MP29
Fig. 1.--Survey area showing flight lines, photo plots, and ground truth plots, Sangre de Cristo Mountains, New Mexico.
- Flight lines
- Photo plots
- Ground truth plots
- Rejected photo plots (clearcut areas)

Figure 2--Number of dead trees per 2.78 acre ground truth plot as a function of photo interpretation.

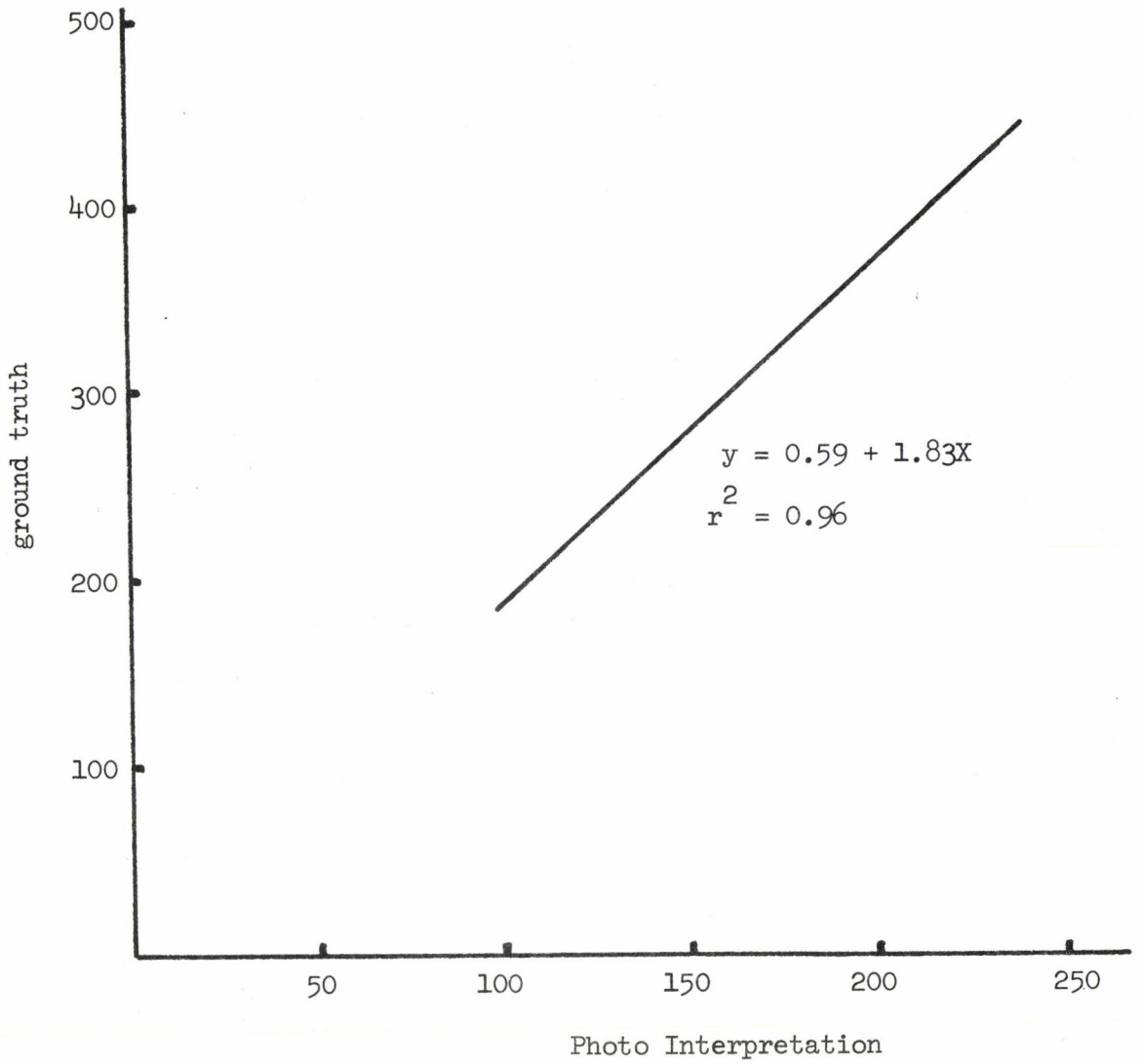

Table 1--Number of dead trees and photo scale for each photo plot.

Plot No.	No. dead trees (x_1)	Photo scale	Plot No.	No. dead trees (x_1)	Photo scale
54	77	1:1,687	164	80	1:3,476
57	163	1:3,842	167	102	1:5,988
60	15	1:5,169	170	25	1:8,498
62	113	1:3,842	173	96	1:9,057
65	95	1:3,842	176	62	1:8,219
68	64	1:2,184	179	83	1:7,940
71	144	1:1,689	182	182	1:8,219
74	118	1:3,511	185	1	1:10,172
77	195	1:3,511	194	11	1:11,288
80	235	1:3,511	209	18	1:4,629
83	159	1:4,506	212	44	1:3,518
86	13	1:5,169	215	2	1:3,518
89	194	1:5,162	218	34	1:5,740
92	12	1:9,705	221	25	1:5,740
95	19	1:7,640	224	73	1:5,740
98	1	1:7,640	227	64	1:6,481
101	70	1:8,466	230	6	1:6,481
104	5	1:3,510	233	7	1:8,333
107	241	1:5,988	236	8	1:6,111
110	26	1:6,814	239	24	1:6,481
113	11	1:6,401	251	137	1:3,638
125	161	1:4,543	254	38	1:3,638
128	191	1:6,095	260	88	1:4,300
137	207	1:4,154	263	99	1:7,608
140	355	1:3,378	266	3	1:4,741
143	57	1:4,154	269	43	1:6,726
146	130	1:6,095	272	3	1:6,726
149	47	1:5,708	275	3	1:8,932
152	1	1:4,543	281	0	1:6,726
			$\bar{Z}$		1:5,748
			SD		2,154
			$\bar{x}_1$	77.2	

Table 2--Number of dead spruce and fir trees per plot for ground truth and photo interpretation.

Plot No.	Photo Interpretation (x_2)	Ground Truth (y_2)
80	235	425
107	241	431
128	191	389
182	182	322
263	99	174
$\bar{x}_2$	189.6	
$\bar{y}_2$		348.2

Table 3--Adjusted trees per acre for dead spruce and fir trees.

$\bar{x}_1$ - mean [1/] tree count on all 58 plots	77.2
$\bar{x}_2$ - mean [2/] tree count on 5-plot photo sample	189.6
$\bar{y}_2$ - mean [2/] tree count on 5-plot ground truth sample	348.2
regression equation [3/] $y = a + bX$	$y = 0.59 + 1.83X$ $r^2 = 0.96$
yrd = adjusted mean tree count $= \bar{y}_2 + b(\bar{x}_1 - \bar{x}_2)$	142.5
adjusted trees per acre = $\frac{yrd}{2.78}$	51.3

1/ From Table 1.
2/ From Table 2.
3/ Fit for regression is significant at the 0.5% level.